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Teachers' Readiness to Use Inquiry-based Learning: An Investigation of Teachers' Sense of Efficacy and Attitudes toward Inquiry-based Learning

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ABSTRACT

The use of inquiry-based learning (IBL) is encouraged in schools, as it has been shown to be an effective method for raising students' motivation in STEM subjects and increasing their understanding of scientific concepts. Nevertheless, IBL is not very often used in classrooms by teachers due to different (perceived) obstacles. Within the Ark of Inquiry project, teacher training sessions were designed that enabled the teachers to experience IBL from different perspectives: Teacher as a learner, teacher as a thinker, and teacher as a reflective practitioner. We expected that the trainings would have an impact on teachers' sense of efficacy (TE), which has been shown to be positively related to teachers' readiness to adopt new teaching methods, and their attitudes toward IBL. Four hundred and ninety-seven teachers from 10 countries were involved in the study. We found that teachers' higher sense of efficacy was related to more positive attitudes toward IBL before the training. The teacher training sessions had a positive effect on the Student Engagement Subscale of TE ($d = 0.16$) and attitudes toward IBL. The strongest positive effects on attitudes were related to the perceived available resources for teaching inquiry ($d = 0.36$) and inquiry being suitable for motivating different students ($d = 0.28$). However, the training did not impact how teachers perceive systemic restrictions. The study concludes that this kind of teacher training can be a suitable method of boosting TE and overcoming some perceived obstacles for adopting IBL in the classroom.

KEY WORDS: inquiry-based learning; teacher efficacy; science, technology, engineering and mathematics learning; teacher training; attitudes toward inquiry

INTRODUCTION

Increasing students' interest in science, technology, engineering, and mathematics (STEM) continues to be one of the major educational priorities in many European countries according to a study where 30 countries were asked about their strategies for improving STEM education (Kearney, 2016). Inquiry-based learning (IBL) is a possible solution to address the issue of students' low motivation for learning STEM subjects and is therefore included in several curriculum reforms in European countries (Kearney, 2016; Rocard et al., 2007; Pedaste, 2017; Pedaste et al., 2016; Pedaste and Mäeots, 2012). IBL is a student-centered way of learning where students develop their own questions to examine, engage in self-directed inquiry (diagnosing problems - formulating hypotheses - identifying variables - collecting data - documenting their work - interpreting and communicating results), and collaborate with each other (National Research Council, 2000; de Jong, 2006; Dorier and Maaß, 2012; Pedaste et al., 2015). The aim of IBL is to stimulate students to adopt a critical inquiring mind and problem-solving aptitudes (Dorier and Maaß, 2012). Guided inquiry, in particular, has been shown to be an effective method for learning science compared to unguided inquiry (Minner et al., 2010; Lazonder and Harmsen, 2016). Within guided inquiry, the teacher or learning environment can give various types of support (e.g., prompts, heuristics, and scaffolds) to the student who is involved in inquiry learning (Lazonder and Harmsen, 2016).

Nevertheless, it has been found that teachers do not apply the inquiry approach in their classrooms as much as expected (Capps and Crawford, 2013a). In a study based on Trends in International Mathematics and Science Study 2007, it was indicated that teacher's level of experience is one possible predictor of utilizing inquiry-based methods in the classroom (Kuzhabekova, 2015). In another study (Isiksal-Bostan et al., 2015), it was found that teaching experience is positively related to beliefs in using traditional teaching approaches but not to beliefs in inquiry-based teaching approaches. Furthermore, Xie and Sharif (2014) did not find a significant relationship between implementation of IBL and teachers' years of experience. Therefore, the relationship between teaching experience and readiness to use inquiry-based approach is not completely clear, and it is not clear whether teacher training should address teachers with different levels of experience differently.

Capps and Crawford (2013a) and Colburn (2000) bring out lack of understanding and knowledge of inquiry as a reason for teachers not using IBL, for example, the definition of inquiry is unclear and teachers do not know what is expected from them. In addition, prior research shows that for an effective implementation of IBL, and teachers must have refined pedagogical content knowledge for IBL (i.e., proper knowledge of orientations congruous with inquiry, learning strategies for implementing inquiry, students' perception of inquiry, inquiry-based teaching materials, and techniques for assessing inquiry) (Crawford, 2000; Davis and Krajcik, 2005).

There are also various other barriers that teachers need to overcome before the new approach can be implemented. These go well beyond a specific knowledge of IBL methods. Anderson (2002) divides barriers into three clusters: Technical, political, and cultural. Among others, technical barriers include teachers' prior commitment to textbooks, challenges of assessment, and difficulties with managing group work. Political barriers concern parental resistance, unsolved conflicts between teachers, and lack of resources. Cultural barriers are connected to teachers' beliefs and values and commitment to prepare students for the next level of education. The relevance of teacher beliefs for using new methods in the classroom has been stressed by several researchers (e.g., Bhattacharyya et al., 2009; McKeown et al., 2016). In addition, Fishman et al. (2003) found that one goal of professional development should be to influence these beliefs.

Even though authors have used varying terminology and clusters to describe the barriers, there are significant similarities. For example, the understanding of inquiry would be a technical barrier according to Anderson's (2002) view. In the PRIMAS study (Dorier and Maaß, 2012), an effort was made to make an empirical model of the challenges related to implementing IBL. For that, a questionnaire was developed to capture problems that teachers expect to face when implementing IBL. Based on the literature, 15 items were composed, and factor analysis revealed the following three factors: System restrictions, classroom management, and resources (Table 1). These were also supported by the open question analysis in the PRIMAS study. Thus, this can be used as a basis for new empirical studies. It also illustrates how the barriers are related to more aspects than just not enough knowledge of how to implement IBL. When comparing the factors to Anderson's (2002) model, then system restrictions mostly overlap with cultural and political barriers, classroom management with technical barriers, and resources with political barriers, respectively.

There is continuous effort to overcome these barriers. To unify the understanding about IBL, Pedaste et al. (2015) conducted a literature review to bring together different views on inquiry in STEM context; and based on that, they created a cyclical model of inquiry describing all the steps of inquiry within STEM. Furthermore, systemic restrictions are tackled on a political level by changing science curricula in European countries (Kearney, 2016), for systemic restrictions include teachers' perceptions about the curriculum not encouraging IBL. An effort to establish change in teachers' beliefs is made through educating teachers.

Teachers' Beliefs and Teacher Training

Literature indicates that teachers' higher sense of efficacy is related to their readiness to adopt new teaching methods such as inquiry (e.g., Voet and De Wever, 2017). Tschannen-Moran and Hoy (2001. p. 783) use the term "teacher efficacy" and conclude from the previous literature that teachers with higher teacher efficacy "are more open to new ideas and are more willing to experiment with new methods to better meet the needs of their students." They defined teacher efficacy as "a judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" and found relationships between teacher efficacy and student outcomes such as achievement, motivation, and students' sense of efficacy. Therefore, in addition to specific skills and IBL-related beliefs (e.g., belief that IBL is very difficult to manage and suitable only for very knowledgeable students), general teacher efficacy should be considered when promoting change in teachers' behavior.

Teacher training has been suggested as an effective way to increase teachers' motivation and readiness to adopt new approaches such as inquiry into their teaching. Different authors have brought out several aspects to be considered by the teacher educators that would make the teacher trainings most effective. Capps and Crawford (2013b) stress the importance of teachers engaging in authentic scientific investigation, supporting teachers in how to use the inquiry approach, and supporting the reflection of teachers. Based on their study results, Voet and De Wever (2017) argue that to achieve positive effects on students, teachers' attitudes toward the inquiry approach and perceived competence to teach IBL, trainings should focus on (1) stimulating active learning, (2) changing beliefs, and (3) providing a practical guide.

Until recently, there have not been many training programs specifically aimed at the inquiry approach and improving teachers' knowledge and attitudes toward it. Yet, there is already some evidence that positive effects can be achieved through specially designed teacher training courses. For example, Ertikanto et al. (2017) report success with a teacher training program implemented in Indonesia that was designed to follow Bandura's stages of social learning (learning by observing): Attention, retention, production, and motivation. The effect was observed on teachers' inquiry skills. Perez and Furman (2016) found that a 10-month professional development course in Peru, which engaged teachers in designing inquiry-based lessons, had a positive impact on teachers' practice of inquiry. The authors concluded that the factors that counted for the change were teachers' revised views, engaging in inquiry activities themselves and trying out the inquiry approach within their classroom.

Table 1: Subscales of the PRIMAS questionnaire with internal consistency measurements

Area	Subscale	Items/description	Cr. alpha	Mean inter-item correlation	N of Items	N
Use of IBL	Routine use of IBL	I already use IBL a great deal	-	-	1	380
Preconception of IBL	Knowledge dependencew	Successful IBL requires students to have extensive content knowledge	0.521	0.353	2	347
		IBL is not effective with lower-achieving students				
	Motivation	IBL is well suited to overcome problems with students' motivation	0.582	0.411	2	345
		IBL is well suited to approach students' learning problems				
Problems with implementation	Resources	I do not have sufficient resources such as computers and laboratory	0.629	0.359	3	375
		I do not have access to any adequate professional development programs involving IBL				
		I do not have adequate teaching materials				
	Classroom management	I think that group work is difficult to manage	0.692	0.360	4	376
		I worry about students' discipline being more difficult in IBL lessons				
		I do not feel confident with IBL. I worry about my students getting lost and frustrated in their learning				
	Systemic restrictions	My students have to take assessments that do not reward IBL	0.654	0.323	4	347
		The number of students in my classes is too big for IBL to be effective				
		The curriculum does not encourage IBL				
		There is not enough time in the curriculum				

IBL: Inquiry-based learning

Furthermore, in the present study, a specially designed model of teacher training was used. This particular model was the result of a thorough literature review of the domain (for details see Irakleous, 2015 and Papaevripidou et al., 2017). During this process, several aspects, which were found to positively affect teachers' understandings about IBL, were combined together to bring the best of the previous models and frameworks together. The overarching outcome of this review was that for a successful teacher training, the teachers need to experience inquiry from different perspectives to capture the whole picture of what IBL is and how it is effectively enacted. To offer the teachers different perspectives on looking into IBL, researchers suggest having the teachers experience inquiry by undertaking different roles (e.g., teachers as learners, teachers as reflective practitioners). As a result, we developed a teacher training model which includes three phases. Each phase corresponds to a different teacher role, namely, teachers as learners, teachers as thinkers, and teachers as reflective practitioners.

The first phase - teachers as learners - positions the teachers in the role of active learners, letting them experience learning as their students do. For instance, stepping into the students' shoes enables teachers to experience issues and struggles similar to those of their students. Prior research has shown this to be beneficial for teachers' professional development (e.g., Clarke and Hollingsworth, 2002; Kazempour and Amirshokoohi, 2014; Kerlin, 2012).

In the second phase - teachers as thinkers - teachers have the opportunity to develop their understanding and knowledge about inquiry (Akerson et al., 2007), for example, through reading about theory and class discussions. In addition, teachers are encouraged to compare the theoretical framework constructed in this phase with the empirical understanding they have gained while experiencing the teachers as learners phase - this enables teachers to put their knowledge into practice and *vice versa*, which results in a better understanding of IBL.

The third phase - teachers as reflective practitioners - concentrates on reflecting on the experience gained in the previous two phases and materializing it by designing and developing inquiry-based teaching materials, which in turn are enacted in science classes. In addition, the teachers are further prompted to reflect on their inquiry implementations. The idea is to have teachers reflect on their failures and successes. Reflection is also an important part of teachers' professional development (Ferraro, 2010).

Although IBL has been found effective and some steps have been taken to overcome the described barriers, it is still not used in the classroom as much as expected and we are therefore still looking for effective ways to promote inquiry (Pedaste

et al., 2016). Furthermore, many of the strategies, policies, and initiatives to improve STEM education are relatively recent, and therefore, it is advised for "the European research and policy-making communities to follow their development and monitor their impact to STEM education progress" (Kearney, 2016. p. 83). Thus, the implementation of IBL in classrooms is still an ongoing endeavor that needs further input from research to identify effective inquiry-based practices and introduce these to teachers (Van Joolingen and Zacharia, 2009).

Aims and Research Questions

Our aim was to find whether our model designed for teacher training would have an effect on teachers' attitudes toward inquiry and their teaching-related sense of efficacy. To address the relationships between teachers' attitudes and the possible effect of the teacher training sessions, we formulated the following three research questions:

1. Is prior use of inquiry and teaching experience related to teachers' attitudes toward inquiry?
   As previous studies have indicated controversial findings about the relationship between teaching experience and readiness to use IBL, we wanted to know whether teaching experience and experience with IBL have a positive effect on attitudes toward IBL or is IBL equally challenging for more experienced teachers.
2. Is teachers' sense of efficacy (TE) related to attitudes toward the inquiry approach?
   Our second research question stands on two assumptions: (1) Attitudes toward IBL predict use of IBL, whereas negative beliefs are seen as barriers to implementing IBL and are therefore relevant mediators; (2) TE is an important prerequisite for teachers' readiness to start using new methods. We assume that teachers' higher sense of efficacy is related to perceiving less barriers for implementing IBL.
3. Do the teacher training sessions have an impact on TE and attitudes toward inquiry and if so in which areas is it more pronounced?
   Essential aspects of effective IBL teacher trainings have been suggested in the literature. We wanted to find whether a teacher training session that considers these aspects has an effect on teachers' attitudes toward IBL, and moreover, on a more general construct of TE.

METHODS

Context

Ark of Inquiry is a research and development project funded by the European Commission (Pedaste et al., 2015; http://arkofinquiry.eu). The project involves 13 partners from 12 countries, who collaboratively aim to promote interest in science through IBL, which is linked to the Responsible Research and Innovation approach (Burget et al., 2016). Within the project, a web platform was created with carefully selected inquiry-based activities, and web-based materials were developed to support guided inquiry. For supporting the teachers, face-to-face trainings were provided to them in all the countries involved in the project, following the aforementioned model of training.

Sample

From all the Ark of Inquiry project partners, 10 countries had the opportunity to collect data about TE and attitudes toward inquiry. The samples are not representative of the countries and the groups are not balanced between countries. The teachers' participation in the trainings was voluntary and they were not paid or charged to take part in the trainings. Answering the questionnaire was part of the training event, although filling in the questionnaires was not obligatory.

Altogether there were 1235 teachers who participated in the trainings. Four hundred and ninety-seven of them also filled in the questionnaires. Pre- and post-test data are available for 228 participants from 7 countries. Most of the participants in the trainings were women (77.9%), and 83.7% of the teachers had at least 6 years of teaching experience. The teachers were from general education schools and taught primary or basic school level. The mean age of the participants was 43. More information about the participants was summarized in Table 2.

It is evident from Table 2 that the number of participants in the trainings was much larger than the available data. This has several reasons. In many cases, this has to do with the dropout of teachers from the program and failure to fill in the questionnaire at the given time and place (e.g., they left before the end of the session). One reason for dropout stems from teachers' busy schedule, due to which in some cases they were not able to attend the second session. It is also important to note that there were teachers who participated in the second session but were not able to attend the first training session. In three countries, the questionnaire was distributed only once during the training sessions.

The distribution of teachers based on their teaching experience can be seen in Table 3. Four teachers did not report their teaching experience.

Instruments

TE scale (Tschannen-Moran and Hoy, 2001) was used to measure TE at the start and at the end of the training. The scale consists of 24 questions designed to capture the three moderately correlated subscales related to being a teacher: Student engagement (e.g., getting students to believe they can do well in schoolwork and helping students value learning), classroom management (e.g., controlling disruptive behavior in the classroom and calming disruptive students), and instructional strategies (e.g., using a variety of assessment tools and implementing alternative strategies in the classroom). Each subscale consists of 8 questions, where teachers indicate on a 9-point scale to what extent they think they can manage in different situations. Both three- and one-factor structures have been found appropriate for use depending on the sample. In the case of preservice teachers, the 1-factor model has had a better fit for the data (Tschannen-Moran and Hoy, 2001).

Table 2: Description of study participants

Country	Overall sample size	Sample size (pre- and post-training data available)	Female proportion (overall sample) (%)	Average age (overall sample)
Belgium	13	3	77	44
Cyprus	45	43	56	45
Finland	106	57	79	42
France	55	0	64	42
Greece	6	0	50	38
Hungary	65	0	82	45
Italy	106	61	94	50
Netherlands	7	6	57	28
Turkey	59	40	71	37
Estonia	35	18	89	39
Total	497	228	78	43

Table 3: Participants' teaching experience (in years)

Years of teaching experience	0–5	6–15	>16
N	77	184	232
% of total	15.5%	37.0%	46.7%

Four teachers (0.8% did not report their teaching experience)

In our sample, we found that the internal consistency of the different subscales was good or very good (Cronbach's alpha ranging from 0.878 to 0.909). Confirmatory factor analysis was used to confirm the factor structure in the current sample. The factor loadings of the items are high in the three-factor model, but the constructs were strongly correlated (ranging from 0.79 to 0.89). A moderate correlation of the subscales was also noted by the authors of the TE scale, ranging from 0.58 to 0.70 (Tschannen-Moran and Hoy, 2001). Based on our data, we see that the 3-factor model is a better fit to the data than 1-factor model (Table 4), although the fit indices of the model are not as good as expected. We used several fit indices to evaluate the model, namely, Chi-square, the root mean square error of approximation (RMSEA; Browne et al., 1993), the comparative fit index (CFI; Bentler, 1990), and the standardized root mean square residual (SRMR; Jöreskog and Sörbom, 1989). We considered the following cutoff values as indicators of good fit: 0.06 or below for the RMSEA, 0.95 or greater for the CFI, and .08 or below for the SRMR (Brown, 2006; Hu and Bentler, 1999). We see that only SRMR indicates a good fit.

Attitudes toward IBL were measured by one part of a questionnaire that was used in the PRIMAS project (Dorier and Maaß, 2012) to analyze teachers' use and preconception of inquiry and their problems with the implementation of IBL. The part of the questionnaire used in the current project consisted of 23 items where teachers were asked to assess on a scale from 1 to 4 how much they agree with the given statements (Table 1 for the subscales and questions used in this analysis. Note that not all questions were used, as the questionnaire covered different topics of which not all were the focus of the current study). The authors of the questionnaire have not provided a factor structure for the use and preconception subscales of IBL (internal consistency measurements were given with Cronbach's alphas varying from 0.54 to 0.60).

Table 4: Model fit of the three-factor structure and one-factor structure of the teachers' sense of efficacy scale

Model fit indicator	1-factor structure	3-factor structure
Chi-square (df; p)	1313.032 (252; <0.001)	1022.014 (249; <0.001)
RMSEA	0.105	0.090
CFI	0.805	0.858
SRMR	0.068	0.061

CFI: Comparative fit index, RMSEA: Root mean square error of approximation, SRMR: standardized root mean square residual

A three-factor structure was found in the PRIMAS project for the subscales about problems with implementing IBL: System restrictions, classroom management, and resources (Table 1). Confirmatory factor analysis was used to confirm the factor structure in the current sample, and the fit was relatively good ($\chi^2(41)=102.6$, $p<0.001$; RMSEA=0.063; CFI=0.928; TLI=0.903; SRMR = 0.049). The factors' correlations with each other varied from 0.49 to 0.84. The internal consistency measurements for the IBL questionnaire were generally low. This was expected due to the low number of questions in each subscale. We also calculated mean inter-item correlations for these subscales as suggested for scales with a small number of items by Briggs and Cheek (1986). Briggs and Cheek (1986) recommend that the optimal mean inter-item correlations range from 0.2 to 0.4. In our sample, the mean inter-item correlations vary between 0.323 and 0.411. Subscales with Cronbach's alphas lower than 0.5 were not used in the study and statistical analysis.

The participants were also asked some questions about their demographics and previous experiences (gender, age, years of teaching experience, and subjects taught).

Procedure

The principles of the teacher training course were developed within the Ark of inquiry project and acted as guidelines/ protocol for all the partners for planning and conducting the training sessions in their countries (see http://www.

arkofinquiry.eu/web-based-materials). The teacher training consisted of three phases (teacher as a learner, teacher as a thinker, and teacher as a reflective practitioner). Phases 1 and 2 were tackled in 1 or 2 days of teacher training depending on whether the teachers had previously hands-on experiences with IBL or not. At the beginning of the first training day, teachers filled in the questionnaire about TE and their attitudes toward IBL. After the second phase, the teachers had a few months to practice IBL in their classrooms. This was followed by one more day of teacher training practice (Phase 3). At the end of this last training day, teachers were asked to fill in the questionnaires again. In total, the teacher training lasted for 2 or 3 days including several months of practice time.

Within the training, the teachers had an opportunity to experience inquiry from the learner's viewpoint. Furthermore, different resources for conducting inquiry were introduced, including the Ark of Inquiry web-based platform with a collection of different inquiry activities that the teachers can use in their lessons. Given the fixed protocol, which all partners had to follow, the time-on-task across all phases was expected to be the same for all partners. No partner has reported deviations from the protocol, including the time-on-task. The questionnaires were filled in online or on paper, depending on whether computers were available for use or not.

An average overall TE score and averages for the three subscales were calculated from the questionnaire data. Average scores were also calculated for the attitudes toward inquiry subscales as suggested by the original authors.

Q-Q plots were used to visually determine whether the distributions of data were approximately normal, and this was found to be the case for the TE scores and IBL subscales. T-tests and one-way ANOVA with Levene's test for equal variance were used for group mean comparisons. In cases where the assumption of equal variances was violated, Welch's t-test was used to determine the statistical difference. In case of very different group sizes (1.5-fold difference), nonparametric tests were preferred. A $p<0.05$ was considered statistically significant for all tests. In cases of multiple comparisons, we used the Holm-Bonferroni Sequential Correction (Gaetano, 2013). The corrected p values are marked with p'. Cases with missing data were excluded analysis by analysis. The data were analyzed with SPSS 20 and Mplus 7.4 software.

RESULTS

The Relationship between Prior Teaching Experience and Teacher Attitudes

The average score for TE before the training was 6.69, and values are ranging from 2.96 to 9.0 (Table 5 for more details). Kruskal-Wallis one-way ANOVA revealed that TE before the teacher training sessions was not related to the years of teaching experience: Comparing teachers with 0–5 (n=77); 6–15 (n=184), and 16 or more years of teaching experience (n=232) revealed no significant differences, $\chi^2(2)=3.891$, $p=0.143$.

Attitudes toward IBL were measured on a scale from 1 to 4 with mean scores, sample size, and SD provided in Table 5. Attitudes toward IBL were similar for teachers with varying levels of experience ($p>0.05$).

The Relationship between Prior Use of Inquiry and Teachers' Attitudes toward Inquiry

Two groups were created based on prior use of IBL (agreement with the statement "I already use IBL a great deal" ranging from 1 to 4). This was used as an indicator for the prior use of IBL and answers 1 ("strongly disagree") and 2 ("disagree") were pooled together into a group labelled "no or very little use;" answers 3 ("agree") and 4 ("strongly agree") were pooled together to form a group "somewhat or high use." This resulted in approximately equally sized groups. Independent samples t-test was used to test for differences in the 5 factors among two groups of teachers. We used Holm-Bonferroni correction to control for Type 1 error and present p' which is the adjusted p value. The test revealed that teachers who already use IBL and those who use it very rarely exhibit significant differences in preconceptions about IBL. These differences are significant for knowledge dependence, $t(343)=3.212$, $p'=0.005$, and classroom management, $t(375)=2.729$, $p'=0.028$, but not for resources, $t(376)=2.089$, $p'=0.074$. The assumption of homogeneity of variance was violated for the motivation subscale; therefore, the Welch-Satterthwaite method was used to adjust degrees of freedom, and a significant difference was found, $t(334)=-2.536$, $p'=0.036$. However, the prior use of IBL is not related to systemic restrictions, $t(376)=1.505$, $p'=0.133$. We have also presented Cohen's *d* that shows the effect size in units of standard deviation (Table 6).

The Relationship between Teachers' Sense of Efficacy and Attitudes toward the Inquiry Approach

The TE score was used to create two groups: Teachers with high (M=7.4) and low TE (M=6.0) (Table 7). These groups were created based on the median score of 6.75. The independent samples T-test revealed that teachers with an overall higher level of TE are more positive toward inquiry and report lower levels of different types of potential restrictions, such as difficulties with classroom management, $t(379)=7.086$, $p'<0.001$; systemic, $t(380)=3.848$, $p'<0.001$ and resource restrictions, $t(380)=3.092$, $p'=0.006$. Furthermore, they see inquiry as a motivation-enhancing tool for students, $t(347)=-2.613$, $p'=0.006$, and not as highly knowledge dependent, $t(347)=3.038$, $p'=0.009$.

Effects of Training on TE

Pre- and post-training data are available for 228 teachers. The mean TE score for these teachers was 6.69 before the training and 6.82 after the training. The effect of training was not evident on the overall score of TE, as revealed by the paired samples t-test, $t(227)=-2.291$, $p'=0.069$, though the effect is notable in the student engagement subscale, $t(227)=-2.290$, $p'=0.016$; no significant difference was found between pre- and post-test measurements of the classroom management [$t(227)=-1.399$, $p'=0.163$] and instructional strategies

Table 5: Pre-training means and standard deviations of the teachers' sense of efficacy and attitudes toward IBL in the sample

Scale	M (scale from 1 to 9)	Range	N	SD
1. Teacher efficacy	6.7	2.96–9.00	382	1.00
1.1 Student engagement	6.6	2.38–9.00	382	1.15
1.2 Classroom management	6.8	2.00–9.00	382	1.11
1.3 Instructional strategies	6.7	3.38–9.00	382	1.02
Scale	**M (scale from 1 to 4)**	**Range**	**N**	**SD**
2. Attitudes toward IBL				
2.1 Knowledge dependence	2.3	1.00–4.00	349	0.71
2.2 Motivation	3.0	1.00–4.00	349	0.61
2.3 Resources	2.5	1.00–4.00	382	0.64
2.4 Classroom management	2.1	1.00–3.75	381	0.57
2.5 Systemic restrictions	2.5	1.00–4.00	382	0.65

IBL: Inquiry-based learning, SD: Standard deviation

Table 6: Attitudes toward IBL among teachers who have used IBL in the classroom and those who have not or have used it very little

Subscale/frequency of use	N	M (scale from 1 to 4)	SD	SE	Cohen's *d*
Knowledge dependence*					
No or very little use	165	2.4	0.69	0.05	0.35
Somewhat or high use	180	2.1	0.73	0.05	
Motivation*					
No or very little use	165	2.9	0.63	0.05	–0.27
Somewhat or high use	180	3.0	0.58	0.04	
Resources					
No or very little use	189	2.6	0.62	0.05	-
Somewhat or high use	189	2.5	0.66	0.05	
Classroom management*					
No or very little use	188	2.2	0.60	0.04	0.28
Somewhat or high use	189	2.0	0.53	0.04	
Systemic restrictions					
No or very little use	189	2.6	0.65	0.05	-
Somewhat or high use	189	2.5	0.66	0.05	

*Differences between the groups are significant ($p<0.05$). IBL: Inquiry-based learning, SD: Standard deviation, SE: Standard error

[$t(227)=-1.896$, $p'=0.118$] subscales of TE. On average, student engagement was 0.178 points higher after the training program (Cohen's *d* value 0.16).

To further analyze the efficacy-enhancing effects of training, a change score was calculated for the participants (subtracting pre-test score from the post-test score). Kruskal–Wallis one-way ANOVA or Mann–Whitney U-test was used to determine whether the change in the TE score is related to specific prior characteristics. It was found that teachers experience as a teacher ($\chi^2(2)=0.810$, $p=0.667$) or prior use of IBL ($U=5616.5$; $p=0.096$) is not related to the effects of training. It was found, however, that the change was notable for teachers with lower average TE (mean rank=85.3) at the start of the training than for those with higher average TE (mean rank=143.2), $U=3197.5$, $p<0.001$.

Effects of Training on Perceived Restrictions of Using IBL

After having an opportunity to try IBL in the classroom and completing the training, teachers' perception of the difficulties decreased, as revealed by the paired samples T-test. The effect of the training was most significant for the perceived lack of resources, $t(227)=6.665$, $p'<0.001$; difficulties managing the classroom, $t(226)=4.087$, $p'<0.001$; and overcoming students' lack of motivation, $t(209)=-3.489$, $p'=0.003$. The training had no significant effect on the preconception about the high knowledge dependence, $t(209) = 2.102$, $p' = .074$; or the sense of systemic restrictions, $t(227)=0.557$, $p=0.578$. Corresponding Cohen's *d* effect sizes can be found in Table 8.

DISCUSSION

IBL has been recommended as an effective method to be used in classrooms (Rocard et al., 2007) with the aim to raise interest in STEM subjects and careers, which is one of the top priorities in current educational policies across Europe (Kearney, 2016). However, there seems to be a gap between what is written in the curricula and what goes on in the classrooms because IBL is not used by the teachers as much as expected by the

Table 7: Attitudes toward IBL among teachers with high and low teachers' sense of efficacy

Subscale	N	M	SD	SE	Cohen's *d*
Knowledge dependence*					
Low teacher efficacy	178	2.4	0.70	0.05	0.33
High teacher efficacy	171	2.1	0.70	0.05	
Motivation*					
Low teacher efficacy	178	2.9	0.58	0.04	−0.28
High teacher efficacy	171	3.0	0.62	0.05	
Resources*					
Low teacher efficacy	200	2.6	0.61	0.04	0.32
High teacher efficacy	182	2.4	0.66	0.05	
Classroom management*					
Low teacher efficacy	200	2.3	0.56	0.04	0.73
High teacher efficacy	181	1.9	0.51	0.04	
Systemic restrictions*					
Low teacher efficacy	200	2.6	0.62	0.04	0.39
High teacher efficacy	182	2.4	0.67	0.05	

*Differences between the groups are significant ($p<0.05$).
IBL: Inquiry-based learning, SD: Standard deviation, SE: Standard error

Table 8: Changes in attitudes toward IBL after the training (only significant changes are shown) positive value indicates an increase after the training

Subscale	Cohen's *d*
IBL is suitable for increasing student motivation	0.277
Resource restrictions	–0.359
Classroom restrictions	–0.303

IBL: Inquiry-based learning

policymakers (Capps and Crawford, 2013a). This is why successful adaptation of the inquiry approach is still a popular research topic. We still have many teachers who have not received sufficient training on the inquiry approach and need support with adopting this method into their teaching, although prior research has shown that teacher training is an effective way to introduce inquiry in a science classroom (e.g., Ertikanto et al., 2017; Perez and Furman, 2016) and help to overcome different barriers related to adoption of IBL.

After a thorough literature review about teachers' professional development concerning the implementation of IBL in science education, we identified the key roles that a teacher needs to undertake for a successful training, namely, teacher as learner, teacher as thinker, and teacher as reflective practitioner. We developed a new training program focusing on introducing IBL to science teachers. This particular program was developed in the context of the Ark of Inquiry project and validated through research. In these training sessions, the teachers had the opportunity to (1) experience IBL as their students would, (2) receive information on the theoretical and empirical underpinnings of IBL and on possible resources that can be used for inquiry-based teaching and learning (such as the Ark of Inquiry web platform), (3) design and implement their own IBL materials or implement existing IBL materials from the Ark of Inquiry web platform in their science classes, and (4) later reflect on these implementations in the presence of their fellow teachers.

As teachers' beliefs are significant predictors of adopting new methods (Voet and De Wever, 2017; Tschannen-Moran and Hoy, 2001), we wanted to know whether this training program would have an effect on TE, which is a more general belief and attitudes toward inquiry, that is more specific. More specifically, we had the following three research questions:

1. Is prior use of inquiry and teaching experience related to teachers' attitudes toward inquiry?
2. Is TE related to attitudes toward the inquiry approach?
3. Do the teacher training sessions have an impact on TE and attitudes toward inquiry, and if so then in which areas, is it more pronounced?

The Relationship between Previous Experiences and Attitudes toward IBL

Similarly to Xie and Sharif (2014), we found that attitudes toward IBL were not related to teaching experience. Thus, teachers' experience in itself is not sufficient to adopt new methods, such as IBL. In the context of teacher training sessions, this suggests that there is no reason to concentrate on specific groups based on teaching experience.

Prior use of IBL was related to attitudes toward IBL. Teachers who had used IBL before compared to the ones who had not (or had very little) perceived fewer restrictions and had more positive attitudes. They believed to a greater extent that IBL is suitable for motivating students and is not a highly knowledge-dependent method. They also believed that this method is not more challenging regarding classroom management. However, there was no difference between groups related to systemic restrictions and available resources, which indicates that practical experience is not enough to overcome all restrictions. Even though the direction of the described connections is not clear, it indicates that positive attitudes toward IBL go hand in hand with first-hand experiences, emphasizing the importance of practical components in trainings.

The Relationship between TE and Attitudes toward IBL

We found that teachers with a higher sense of teacher efficacy have more positive attitudes toward IBL even before the training sessions. The relationship was the biggest related to the attitude concerning classroom management when using IBL. This may be explained by the fact that one subscale of TE is related to classroom management; therefore, it makes sense that there is a strong relationship between the two. This means that teachers with a higher sense of efficacy are more confident about their classroom management skills and this applies also to classroom management in the context of IBL lessons as well. Tschannen-Moran and Hoy (2001) have also concluded that teachers with a higher sense of teacher efficacy are more open to new ideas and more willing to experiment with new methods.

The Effects of the Teacher Training Sessions

When comparing the pre- and post-questionnaire data, we found that TE and attitudes toward inquiry were generally higher after the training sessions, which indicates a positive effect of the training. If we compare the training within our project to other trainings that have been found to be effective, we see that they have some mutual elements such as authentic experience, opportunity for reflection, and opportunity to gain new knowledge (Papaevripidou et al., 2017). Within the TE subscales, the only significant effect was in the Student Engagement subscale. This can be explained by the fact that inquiry is supposed to engage students more compared to traditional teaching (de Jong, 2006; Pedaste et al., 2013). It may be that the teachers had positive experiences with IBL, which in turn impacted their general belief of how well they can engage students. Furthermore, they were now equipped with a new method for better engaging different students.

The attitudes toward IBL were also more positive after the training sessions. Teachers now saw that there were more resources for inquiry, probably because during the training sessions they saw where they could get and how to make different inquiry activities. After the training, there was a decrease in the view that the classroom is difficult to manage during IBL lessons. Furthermore, teachers now found to a greater extent that inquiry is suitable for motivating students. The change in these attitudes may be not only due to greater knowledge gained in the training but also the experiences with IBL in their classroom. However, the attitudes toward knowledge dependence and systemic restrictions did not change. This latter is to be expected because these attitudes not only cannot be tackled with trainings if they are real but also the trainings did not concentrate on the fact that inquiry is actually encouraged by the curricula. It may be that even if it is encouraged by the curricula, it is still not the skill that is evaluated. How to change systemic restrictions, real and perceived, seems to be a challenge, we still have to face. However, we also saw that teachers who had a higher sense of efficacy at the beginning of the course saw fewer systemic restrictions. We speculate that teachers with a higher sense of efficacy feel they can overcome the perceived restrictions and manage to incorporate new teaching methods into the frame provided by the school system. If this is the case, addressing and enhancing beliefs about teacher efficacy are a potential way to overcome systemic restrictions.

As the Ark of Inquiry project is international, we had the opportunity to collect data from several countries. Thus, our sample was relatively big, and we saw that the positive effects were apparent even in such a diverse sample. Nevertheless, there are some limitations to our research. First, our study did not include a control group, and therefore, we do not know whether similar results would have emerged in a purely theoretical training course. Second, we saw a dropout of participants during the study which means that we could draw or conclude based on only these teachers who completed both pre- and post-questionnaires. Furthermore, we do not know whether the positive effects we see are stable and actually carry over to the classrooms. For example, Voet and De Wever (2017) found that training had a positive effect on pre-service teachers' IBL-related attitudes, but their teaching experience during the internship following the training had a negative effect. This may be different for in-service teachers. Therefore, more longitudinal studies are needed to know if and how the positive effects of the training carry over to teaching practice. Furthermore, it is not clear whether the training has an effect on both general (TE) and specific beliefs (attitudes toward IBL) or one is mediated by the other. Further studies could also incorporate specific IBL-related efficacy. Although we had a considerable sample with participants from 10 different countries, we cannot consider our sample representative, as the teacher training courses were voluntary-based and the number of participants varied between countries, and thus, some countries may have had a stronger effect on the results. Further research is needed to find whether there are differences between the countries, and if yes, then what the cause of these may be.

Further research would also benefit from an improved scale for measuring attitudes toward IBL. The scale in this research was a part of a scale used in a similar project implementing the inquiry approach (Dorier and Maaß, 2012). Unfortunately, in our study, the scales of the instrument did not result in as good internal reliability as in the original study, as the Cronbach's alphas were rather low. This is also a significant limitation of our study. We considered the possibility that this was due to the small number of items (2–4 items) in the scales that resulted in low Cronbach's alphas. To overcome this, we used mean inter-item correlation that has been suggested as an internal reliability estimate in case of low number of items in the scale (Briggs and Cheek, 1986). We found that the mean inter-item correlations were in the optimal range (0.2–0.4) suggesting that the scales are indeed unidimensional despite the low Cronbach's alphas.

Overall, we conclude that the three-phase training enabled teachers to have positive experiences with using inquiry within a supportive network of peers and teacher educators, as shown in previous research (Papaevripidou et al., 2017). We also conclude from the results that this program can be used for groups with different amounts of previous experience as a teacher. Although the training was quite minimalistic, consisting of workshops lasting for 2–3 days and an assignment between the workshops, it incorporated significant elements that enabled the change in TE and attitudes toward IBL. When training in-service teachers, it is important to take into account that highly time-consuming training may not be suitable for them, and the cost-effectiveness of the training is also a factor to be considered.

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